

# Northern Hemisphere Winter Climate Response to Greenhouse Gas, Ozone, Solar and Volcanic (Abstract)

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*Northern Hemisphere Winter Climate Response to Greenhouse Gas,  
Ozone, Solar and Volcanic Forcing (Abstract)*

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The Goddard Institute for Space Studies (GISS) climate/middle atmosphere model has been used to study the impacts of increasing greenhouse gases, polar ozone depletion, volcanic eruptions, and solar irradiance changes. We focus on the projection of the induced responses onto Northern Hemisphere winter surface climate. Changes in the model's surface climate take place largely through enhancement of existing variability patterns, with greenhouse gases, polar ozone depletion and volcanic eruptions primarily affecting the Arctic Oscillation (AO) pattern. Perturbations descend from the stratosphere to the surface in the model by altering the propagation of planetary waves coming up from the troposphere, in accord with observational evidence. Models lacking realistic stratospheric dynamics fail to capture these wave flux changes. The results support the conclusion that the stratosphere plays a crucial role in recent AO trends. We show that in our climate model, while ozone depletion has a significant effect, greenhouse gases are the only forcing capable of causing the large, sustained increase in the AO observed over recent decades. This suggests that the AO trend, and a concurrent strengthening of the stratospheric vortex over the Arctic, are very likely anthropogenic in origin.